

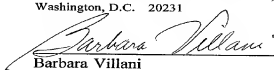
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Pursuant to 37 CFR 1.53(b), transmitted herewith for filing is the patent application of

Inventor(s): Junichi ITO

Title: "CAMERA HAVING SHAKE CORRECTION DEVICE MOUNTED THEREON"

Priority Claim (35 U.S.C. 119) is made, based upon:

JAPAN

NO. 11-149996

MAY 28, 1999

## Enclosed herewith are:

- ☒ Specification (Description, Claims, Abstract): Pages 1 - 60; Number of claims 1 - 34
- ☒ Declaration and Power of Attorney ☒ executed; ☐ unexecuted (supplied for information purposes)
- ☒ 16 Sheets of drawings, Figures 1 - 16 ☒ Formal ☐ Informal
- ☒ Assignment and "Patents" Recordation Form Cover Sheet (PTO-1595) AND \$40. RECORDATION FEE.
- ☒ Certified copy (ies) of priority document(s) identified above
- ☒ Information Disclosure Statement; ☒ Form PTO-1449
- ☐ Preliminary Amendment
- ☐ Verified Statement(s) Claiming Small Entity Status
- ☒ Receipt Postcard

	Number Filed		Number Extra		Rate		Calculations
Total Claims	<u>34</u>	-20 =	<u>14</u>		x \$18.00 =		\$ <u>252.00</u>
Independent Claims	<u>6</u>	-3 =	<u>3</u>		x \$78.00 =		\$ <u>234.00</u>
MULTIPLE DEPENDENT CLAIMS					+ \$260.00 =		\$ _____
					BASIC FEE		\$ <u>690.00</u>
					Total of above Calculations		\$ <u>1,176.00</u>

To the extent not tendered by check, authorization is given to charge any fees under 37 CFR 1.16 and 1.17 during pendency of the application, or to credit any overpayment, to Deposit Account No. 06-1378. Duplicate copy of this letter is enclosed.

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TITLE OF THE INVENTION

CAMERA HAVING SHAKE CORRECTION DEVICE MOUNTED THEREON

CROSS-REFERENCE TO RELATED APPLICATIONS

5 This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 11-149996, filed May 28, 1999, the entire contents of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

10 This invention relates to a shake (or jiggle) correction device mounted on an optical device such as a camera and more particularly to a shake correction device for correcting the deterioration of an image due to shake by use of a wedge prism whose index of  
15 refraction is electrically changed.

Conventionally, when photographing is made by use of a camera held in hand, a problem of deterioration of an image due to shake caused at the time of photographing occurs and various techniques are developed to  
20 solve the problem. The shake correction technique is widely applied to an optical device such as a binocular in addition to a camera.

Generally, in a film camera, a technique using a shake preventing lens which is disposed in a photographing lens system and moves to prevent the vibration  
25 of an image and a driving mechanism for driving the lens is known.

However, use of the driving mechanism for the shake preventing lens makes the photographing lens system larger and since the lens is mechanically driven by the driving mechanism, the movement of the lens cannot follow the shake and a time delay occurs in the shake preventing operation in some cases.

Further, in a camera having an image sensing device such as a CCD, there is provided a shake correction device in which a light receiving area (total pixel number) of the CCD image sensing device is set larger than a light receiving area (effective pixel number) for actually converting received light into an image and which is used for detecting a movement vector of image data photographed by pixels in a preset position and correcting the image itself by an electrical process. However, in the shake correction device utilizing the image sensing device, there occurs a problem that the image quality is lowered and the image processing operation is complicated.

In Jpn. Pat. Appln. KOKAI Publication No. 06-148730 filed by the applicant of this invention, there is proposed an optical shake correction device as the shake correction device using an electrical polarizing member, that is, a liquid crystal prism (wedge prism) which can change the inclination of a light beam passing therethrough according to a voltage applied thereto without using a mechanical driving

mechanism.

The shake correction technique is a technique for using a wedge prism formed by sealing a liquid crystal which is an optical anisotropic medium into a space defined by two glass plates combined to form a wedge shape and applying a voltage corresponding to a detection signal detected by an acceleration sensor to the wedge prism so as to change the index of refraction and deflect the light beam in a direction opposite to the shake direction, thus moving the image to correct the shake.

When the wedge prism in the technology disclosed in Jpn. Pat. Appln. KOKAI Publication No. 06-148730 is used, there occurs a problem that the wedge prism must be driven by use of the open loop control process.

That is, in a conventional vibration preventing device of a type for driving the lens or displacing part of the optical system, a correction amount can be detected by use of some sensor. By feeding back the correction amount, an adequate correction amount can be controlled.

However, in the wedge prism, since the external shape does not change even if a voltage is applied thereto, the correction amount cannot be fed back and it is impossible to monitor whether or not the wedge prism inclines the light beam as designed.

Further, a variation occurs in the physical

characteristic of the wedge prism caused at the time of manufacturing and the characteristic cannot be unconditionally set.

Therefore, when the wedge prism is used in the shake correction device of the camera, it is necessary to previously get information on the relation between the driving voltage and the inclination of the light beam passing through the wedge prism for each wedge prism.

#### BRIEF SUMMARY OF THE INVENTION

An object of this invention is to provide a shake correction device for acquiring and holding parameters indicating the relation between the deflection angle of a light beam and an application voltage to each wedge prism used in the shake correction device mounted on an optical device such as a camera and correcting a shake correction amount based on a shake amount detected at the time of shake correction according to the parameters to effect an adequate shake correction process.

In order to attain the above object, this invention provides a shake correction device comprising: an image sensing device for converting a subject image to image data; a shake detecting section for detecting a shake state; a prism portion for changing an angle of a light beam passing therethrough according to a voltage applied thereto;

an application voltage generating section for  
generating a voltage applied to the prism portion;  
a storage section for storing the relation between  
the voltage applied to the prism portion and the  
5 deflection angle of the light beam passing through  
the prism portion; a control section for determining  
a voltage to be applied to the prism portion based on  
an output of the shake detecting section and an output  
of the storage section and controlling the voltage  
10 generating section to generate the thus determined  
application voltage; and a setting section for  
selectively setting one of an image sensing mode for  
image-sensing the subject image and a test mode for  
measuring the relation between the voltage applied to  
15 the prism portion and the deflection angle of the light  
beam passing through the prism portion which is stored  
in the storage section by use of the image sensing  
device.

Further, this invention provides an electronic  
20 still camera comprising: an image sensing device for  
converting a subject image to image data; a shake  
detecting section including a first shake angle  
detecting section for detecting a shake angle in  
a first axial direction and a second shake angle  
25 detecting section for detecting a shake angle in  
a second axial direction perpendicular to the first  
axial direction; a prism portion for changing an angle

of a light beam passing therethrough according to  
a voltage applied thereto; a temperature measuring  
circuit for measuring a temperature of the prism  
portion; an application voltage generating section  
5 for generating a voltage applied to the prism portion;  
a storage section for storing the relation between the  
voltage applied to the prism portion, the deflection  
angle of a light beam passing through the prism portion  
and the temperature of the prism portion; a control  
10 section for determining a voltage to be applied to the  
prism portion based on an output of the shake detecting  
section and an output of the storage section and  
controlling the voltage generating section to generate  
the thus determined application voltage; and a setting  
15 section for selectively setting one of an image sensing  
mode for image-sensing the subject image and a test  
mode for measuring the relation between the voltage  
applied to the prism portion and the deflection angle  
of the light beam passing through the prism portion  
20 which is stored in the storage section by use of the  
image sensing device.

In the shake correction device with the  
construction described above, the parameters indicating  
the relation between the voltage applied to the wedge  
25 prism and the inclination angle of a light beam is  
stored in the storage section. When a shake amount in  
the optical system is detected by the shake detecting

means, application voltage data corresponding to the shake amount is read out from the storage section, a voltage based on voltage data corrected according to a temperature of the camera is applied to the wedge prism so as to change the index of refraction of the  
5 wedge prism and deflect the light beam in a direction opposite to the shake direction, thus correcting the shake.

The parameters indicating the relation between the  
10 voltage applied to the wedge prism and the inclination angle of a light beam is derived by making a reference light beam incident on the optical system in which the wedge prism is disposed, applying a voltage to the wedge prism at this time to change the index of  
15 refraction thereof, measuring a distance by which the reference light beam moves from a preset position of the image sensing device disposed on the focal plane of the optical system, and determining the relation between the voltage applied to the wedge prism and the  
20 inclination angle of the light beam. The parameters are formed as a data table and stored in the storage section.

Additional objects and advantages of the invention will be set forth in the description which follows, and  
25 in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and



obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

5 The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention, and together with the general description given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

10 FIG. 1 is a diagram showing an example of the schematic construction of an electronic still camera containing a shake correction device according to a first embodiment of this invention;

15 FIG. 2 is a diagram showing an example of the constructions of a wedge prism and a driving circuit therefor shown in FIG. 1;

20 FIGS. 3A and 3B are flowcharts for illustrating the main operation of the camera in the first embodiment;

FIG. 4 is a view showing an example of the structure for measurement of the wedge prism characteristic in the first embodiment;

25 FIG. 5 is a conceptual view of a reference light source unit shown in FIG. 4;

FIG. 6 is a view showing the structure using a chart for measurement of the wedge prism characteristic

in the first embodiment;

FIGS. 7A and 7B are flowcharts for illustrating the sub-routine of measurement of the wedge prism characteristic in the first embodiment;

5        FIG. 8 is a view showing pixel data positions in an area X necessary for measurement of the wedge prism characteristic in the first embodiment;

10        FIG. 9A shows one example of a projection pattern for forming an image on the image sensing device at the turn-ON time of an X-axis measurement light source;

FIG. 9B shows a state obtained by plotting image data of the area X;

15        FIG. 10 is a diagram showing an example of the schematic construction of a silver halide film camera containing a shake correction device according to a second embodiment of this invention;

FIGS. 11A and 11B are flowcharts for illustrating the main operation of the camera in the second embodiment;

20        FIG. 12 is a flowchart for illustrating an external control mode shown in FIGS. 11A and 11B;

25        FIGS. 13A and 13B are flowcharts for illustrating a process for forming a data table necessary for control by measuring the prism characteristic in the second embodiment;

FIG. 14 is a diagram showing an example of the schematic construction of an optical device other than

a camera which contains a shake correction device according to a third embodiment of this invention;

FIG. 15 is a view showing a modification for measuring the prism characteristic by use of a one spot  
5 light source; and

FIG. 16 is a view showing a pattern of spot light applied to the image sensing device in the case of the modification for characteristic measurement shown in  
FIG. 15.

10 DETAILED DESCRIPTION OF THE INVENTION

There will now be described embodiments of this invention in detail with reference to the accompanying drawings.

FIG. 1 shows an example of the schematic  
15 construction of an electronic still camera containing a shake correction device as a first embodiment of this invention.

The camera roughly includes a photographing optical system 1, an image-sensing image processing  
20 section 2, a shake (or jiggle) correcting section 3, and a system controller (CPU) 4 for controlling the above constituents and the whole portion of the camera and further includes a power switch 5, a release switch 6, a temperature measuring circuit 7 for measuring the  
25 temperature of the camera, a photometry circuit 8 for measuring the luminance of a subject, and a test terminal 9 and the like which will be described later.

The opening of a diaphragm 14 which will be described later and the shutter period (integrated time) of an image sensing device are determined based on luminance information obtained by the photometry circuit 8.

5           Since the characteristic of the index of refraction of the wedge prism varies with a change in the ambient temperature, it is necessary to make shake correction according to the temperature and the temperature measuring circuit 7 makes temperature  
10       measurements to correct a driving voltage of the wedge prism.

          The photographing optical system 1 includes a photographing lens 11 for forming an image of the subject, a lens driving mechanism 12 having an actuator  
15       such as a motor for moving the photographing lens 11 to a desired position on the optical axis, a lens driving circuit 13 for driving the lens mechanism 12 under control of the CPU 4, a diaphragm 14 for controlling the light amount, a diaphragm driving mechanism 15  
20       having an actuator such as a step motor for driving the diaphragm 14 and a diaphragm driving circuit 16 for driving the diaphragm driving mechanism 15 under control of the CPU 4 to set the diaphragm opening to a desired value.

25           The shake correcting section 3 includes a shake detecting portion 17, shake correcting portion 18 and nonvolatile memory (EEPROM) 19. The EEPROM 19 stores

driving parameters which become necessary when a wedge prism 20 for correction which will be described later is driven.

5           The shake correcting portion 18 includes the wedge prism 20 and a driving circuit 21 for driving the same. The wedge prism 20 is formed by sealing a liquid crystal whose index of refraction is changed by applying a voltage thereto into a space defined by two glass plates combined to form a wedge shape and the  
10       detail thereof is described in Jpn. Pat. Appln. KOKAI Publication No. 6-148730 filed by the applicant of this invention and explained in the "BACKGROUND OF THE INVENTION" and the detail explanation thereof is omitted here.

15           The wedge prism 20 includes an X-axis wedge prism 20a for correcting the shake of the camera in the X direction or in the vertical direction which is perpendicular to the optical axis of the photographing lens disposed near the diaphragm 14 and a Y-axis wedge  
20       prism 20b for correcting the shake of the camera in the Y direction which is the horizontal direction perpendicular to the optical axis and X axis. The X-axis wedge prism 20a can deflect a light beam passing through the prism according to a driving signal from  
25       an X-axis prism driving circuit 21a which is controlled by the CPU 4. Likewise, the Y-axis wedge prism 20b can deflect a light beam passing through the prism

according to a driving signal from a Y-axis prism driving circuit 21b.

5       The shake detecting portion 17 includes a shake detection gyro 22 and an integrating circuit 23 for integrating an angular speed signal detected by the gyro.

10       The shake detection gyro 22 includes an X-axis shake detecting gyro 22a for detecting a shake angle in the X-axis direction and a Y-axis shake detecting gyro 22b for detecting a shake angle in the Y-axis direction. The integrating circuit 23 includes an X-axis integrating circuit 23a for integrating an angular speed signal in the X-axis direction and a Y-axis integrating circuit 23b for integrating an angular speed signal in the Y-axis direction.

15       As the shake detecting gyro which can be used in the camera, a vibration gyro is provided as a representative example and widely used.

20       Further, the shake detecting portion 17 includes an analog multiplexer 24 for selecting one of two angular speed signals from the integrating circuit 23 under control of the CPU 4 as required, an A/D converter 25 for converting a selected angular speed signal into a digital signal and supplies the same to the CPU 4, and a reset circuit 26 for initializing the two integrating circuits 23.

25       The image-sensing image processing section 2 is

explained below.

The image-sensing image processing section 2 includes an image sensing device 27 formed of a CCD or the like, an A/D converter 28 for converting a subject image (analog signal) photographed to image data which is a digital signal, a timing pulse generating circuit 29 for generating a pulse signal for driving the image sensing device 27, a liquid crystal monitor 30 for displaying a photographed image, an image display circuit 31 for driving the liquid crystal monitor 30, a DRAM 32 used for temporarily storing image data and processing and modifying the image data, a communication interface circuit 34 for making communication with an external control device 33, image data recording media 35 for recording image data, and an image data controller 36 containing a DSP for performing the modification or the like of photographed image data and control of the constituents such as the image sensing device 27 according to an instruction of the CPU 1.

Image data fetched into the DRAM 32 is converted into a preset format under control of the DSP 36 and then stored into the image data recording media 35. As the recording media, a hard disk, flash memory, floppy disk and the like can be provided.

The power switch 5 is an operation switch for determining the operative state or non-operative state of the camera system and if it is set in the ON state,

the operations of the respective constituents can be effected. When the release switch 6 is set in the OFF state, the preparing operation for photographing such as the range finding and photometry is effected, and when the release switch 6 is turned ON, the image sensing process or shake correcting process is effected. The test terminal 37 is used when the measuring operation for the characteristic of the wedge prism 20 which will be described later is effected.

When the test terminal 37 is short-circuited, the measuring operation can be effected. When adjustment for shake correction is made at the time of manufacturing of the camera, signals necessary for the measuring operation are output from an X-axis timing signal output terminal 38 and Y-axis timing signal output terminal 39 during the measuring operation of the wedge prism 20.

The communication interface 34 is a circuit which is used for communication with the external control device 33 represented by a personal computer (PC) and which becomes necessary when image data is transferred from the camera to the external control device 33 and then modified, for example.

FIG. 2 shows the constructions of the wedge prism 20 shown in FIG. 1 and the driving circuit 21 for driving the same. In this example, the X-axis wedge prism 20a and the X-axis wedge prism driving circuit



21a for driving the prism are explained as an example, but the same explanation can be applied to the Y-axis wedge prism 20b and Y-axis wedge prism driving circuit 21b.

5           The X-axis wedge prism driving circuit 21a includes a bridge circuit 41 having transistors Q1 to Q4 and connected to the electrodes of the X-axis wedge prism 20a to apply an AC voltage thereto, a DC/DC converter 42 for supplying a voltage from the power supply side of the camera to the bridge circuit 41, a voltage lowering circuit 43 for setting the output of the DC/DC converter 42 to a voltage value which is applied to the bridge circuit 41, a D/A converter 44 for freely setting a voltage used as a reference of the output voltage value of the voltage lowering circuit 43, and a clock output circuit 45 and inverter 46 for controlling the switching operation of the bridge circuit 41 to cause an AC voltage to be generated.

20           With the above construction, the power supply voltage of the camera is supplied to the DC/DC converter 42 and a voltage higher than the maximum voltage applied to the wedge prism 20 is output to the voltage lowering circuit 43. The voltage lowering circuit 43 includes a series circuit of resistors Ra, Rb, an operational amplifier 47 for outputting a difference between a voltage value obtained by the voltage dividing ratio of the resistors and a voltage

value ( $V_{DAC}$ ) from the D/A converter 44, and a transistor Q0 for lowering the voltage to a necessary driving voltage ( $V_{LCD}$ ) according to the difference output and outputting the driving voltage.

5           The driving voltage  $V_{LCD}$  can be freely set according to the output voltage  $V_{DAC}$  of the D/A converter 44. The following equation (1) can hold between the voltages  $V_{LCD}$  and  $V_{DAC}$ .

$$V_{LCD} = (R_a + R_b)/R_b \times V_{DAC} \quad \cdots (1)$$

10           The bridge circuit 41 converts the voltage ( $V_{LCD}$ ) to an AC voltage by alternately turning ON/OFF a pair of transistors Q3 and Q2 and a pair of transistors Q1 and Q4 by the action of the clock output circuit 45 and inverter 46 and supplies the AC voltage to the wedge prism 20.

15           Then, if information on the relation between the application voltage (setting value of the D/A converter) and the deflection angle caused by the wedge prism 20 is acquired, the CPU 4 can change the direction of the light beam passing through the prism by a desired angle.

20           The shake angle of the camera can be detected by integrating the shake amounts detected by the X-axis, Y-axis detecting gyros 22a, 22b. By deflecting the light beam passing through the X-axis, Y-axis wedge prisms 20a, 20b in a direction to cancel the shake angle, a subject image formed by the photographing lens

stands still in its position as if it is fixed in the space.

5 This embodiment attains shake correction by deflecting the light beam in an opposite direction (in a canceling direction) by an angle corresponding to the shake angle by use of the wedge prism.

The main operation of the camera of this embodiment is explained with reference to the flowcharts shown in FIGS. 3A and 3B.

10 First, the power switch 5 is turned ON, the power supply voltage is supplied to the system of the camera and the CPU 4 starts the operation to effect the initialization process (step S1). In the initialization process, the I/O port, memory and circuits  
15 connected to the CPU 4 are initialized.

Then, whether or not the test terminal 37 is set in the test mode is determined (step S2). Specifically, when the test terminal 37 is set in the short-circuited state, the test mode is determined  
20 (YES) and the sub-routine "measurement of wedge prism characteristic" which will be described later is executed (step S3). If the test terminal 37 is not set in the test mode (NO), the normal operation mode is determined and the present temperature data of the  
25 camera measured by the temperature measuring circuit 7 is input (step S4).

Next, voltage data indicating the voltage values

to be applied to the X-axis, Y-axis wedge prisms 20a, 20b and stored in the EEPROM 19 are read out and input to the CPU 4 (step S5). In the EEPROM 19, a data table for selecting voltage data is stored.

5 For example, in the following table 1, the data table indicating necessary application voltages for controlling the X-axis wedge prism 20a is set.

Table 1

Temperature X-axis light beam deflection angle	-10-0(°C)	1-10(°C)	11-30(°C)
+1.0(Degree)	3.5(V)	2.5(V)	1.5(V)
+0.8	4.0	3.0	2.0
+0.6	4.5	3.5	2.5
+0.4	5.0	4.0	3.0
+0.2	5.5	4.5	3.5
0.0	6.0	5.0	4.0
-0.2	6.5	5.5	4.5
-0.4	7.0	6.0	5.0
-0.6	7.5	6.5	5.5
-0.8	8.0	7.0	6.0
-1.0	8.5	7.5	6.5

※1

※2

10 It is necessary to change the data table according to the temperature change when taking the temperature characteristic of the portions constituting the wedge prism 20. In the example shown in the table 1, it is supposed that the temperature range in which the camera is used is divided into three regions.

For example, if the temperature measured in the step S4 is 20°C, the data table shown in ※1 is read out from the EEPROM 19. Likewise, the data table for the Y-axis wedge prism 20b is set in the EEPROM 19 and the data table corresponding to 20°C is read out.

Next, in order to apply a centering voltage indicated in ※2 to the X-axis wedge prism 20a from the data table in the table 1, an output of the D/A converter 44 in the X-axis prism driving circuit 21a is set (step S6). Likewise, setting by the centering voltage is made for the Y-axis wedge prism 20b.

Generally, in a system for correcting shake by shifting or tilting part of the lens group of the photographing optical system, the lens group is moved to a neutral position (the center of the shifting or tilting range) prior to the shake correcting operation. The operation is called a centering operation.

In a case wherein the shake correcting operation is effected by use of the wedge prism 20 as in this embodiment, an operation corresponding to the centering operation as shown in the step S6 is necessary. By applying the centering voltage, the light beam passing through the wedge prism will pass therethrough without being deflected. If a voltage lower than the centering voltage is applied, the light beams is deflected in the positive direction (+ direction). Further, if a voltage higher than the centering voltage is applied,

the light beams is deflected in the negative direction (- direction).

5       The operations of the temperature measurement, the voltage readout of the wedge prism and the application of the centering voltage in the steps S4 to S6 are periodically effected. Therefore, the data table corresponding to the temperature change is adequately read out from the EEPROM 19 even if the temperature of the camera is changed and an adequate voltage is  
10       applied to the wedge prism 20.

      Then, luminance data of the subject is input from the photometry circuit 8 and the exposure, that is, the shutter period (integration time of the image sensing device) and the opening of the diaphragm 14 are  
15       calculated (step S7). After the shutter period and the opening of the diaphragm are set, the CPU 4 issues an instruction to the DSP 36 so as to start the integrating operation of the image sensing device 27 (step S8).

      Next, after preset time is set in a timer counter,  
20       the operation thereof is started (step S9) and it waits until the preset time set in the timer counter elapses (step S10).

      If the preset time has elapsed (YES), the CPU 4 issues an instruction to the DSP 36 to fetch image  
25       data. In response to the instruction, the DSP 36 interrupts the integrating operation of the image sensing device 27, fetches the image data and stores

the image data into the DRAM 32 (step S11). After this, the DSP 36 is instructed to display the image data and causes the liquid crystal monitor 30 to display the fetched image data.

5           Next, whether the release switch 6 is set in the OFF state or not is determined (step S13) and if it is set in the OFF state, the ON/OFF state of the power switch 5 is detected (step S14). If the power switch 5 is set in the ON state, the process returns to the step  
10       S4 and the CPU 4 continues the operation. However, if it is set in the OFF state, the system interruption process is effected (step S15) and the operation of the CPU 4 is interrupted.

          If it is detected in the step S13 that the release  
15       switch 6 is set in the ON state, the diaphragm is set to a diaphragm opening determined in the step S7 by the diaphragm driving mechanism 15 (step S16) and the X-axis, Y-axis integrating circuits 23a, 23b are initialized (step S17). The deflection angle can be  
20       detected by integrating the outputs of the X-axis, Y-axis detecting gyros 22a, 22b. Therefore, at the starting time of the shake correcting operation, the X-axis, Y-axis integrating circuits 23a, 23b are initialized by use of the reset circuit 26 to reset  
25       the output values thereof to a reference value.

          Next, the CPU 4 instructs the DSP 36 to start the integrating operation of the image sensing device 27

(step S18). In response to the instruction, the DSP 36 starts the time counting operation of the timer counter for measuring the shutter period set in the step S7 (step S19). Then, whether the counting time of the timer counter reaches the set shutter period or not is determined (step S20).

As the result of the above determination, if it is detected that the set shutter period is not reached (NO), the CPU 4 causes the analog multiplexer 24 to select the output of the X-axis integrating circuit 23a, the output is converted to a digital signal by the A/D converter 25 and then shake in the X direction (camera deflection angle) is calculated in the CPU 4 (step S21).

A voltage applied to the X-axis wedge prism 20a is derived based on the calculated camera deflection angle and table data read out from the EEPROM 19 (step S22). For example, if the camera deflection angle is -0.4 degree, the light beam may be deflected by +0.4 degree by use of the X-axis wedge prism 20a. In this case, as a voltage applied to the X-axis wedge prism 20a, a voltage of 3.0 V is selected from ※1 in the table 1. The D/A converter 44 of the X-axis wedge prism driving circuit 23a is set so as to apply the application voltage to the X-axis wedge prism 20a (step S23).

Further, if the camera deflection angle is set to an angle such as -0.45 degree which does not exist on



the table, an intermediate value may be derived based on application voltage data items for +0.4 degree and +0.6 degree.

Likewise, in the case of shake in the Y-axis direction, a voltage applied to the Y-axis wedge prism 20b is derived based on the camera deflection angle and the D/A converter 44 of the Y-axis wedge prism driving circuit 23b is set (steps S24 to S26). After the setting, the process returns to the step S20. Since the process of the steps S21 to S26 is repeatedly effected at high speed during the integrating operation of the image sensing device 27, a subject image on the image sensing device 27 is fixed irrespective of shake occurring in the camera.

If it is detected in the step S20 that the preset shutter period has elapsed (YES), the CPU 4 issues an instruction to the DSP 36 to fetch image data (step S27). In response to the instruction, the DSP 36 interrupts the integrating operation of the image sensing device 27, reads out image data from the image sensing device 27 and stores the readout data into the DRAM 32.

Next, the CPU 4 issues an instruction to the DSP 36 to form an image file (step S28). The DSP 36 converts fetched image data into a preset format to form an image file and stores the same into the image data recording media 35.

After the storage process is completed, the diaphragm 14 is driven to an open state (step S29), the process returns to the step S4 and the same process is repeatedly effected.

5       Next, the sub-routine "measurement of wedge prism characteristic" of the step S3 shown in FIG. 3 is explained.

10       When the sub-routine is executed, as shown in FIG. 4, a camera 51 is mounted on a bench 52 to face a reference light source unit 53 which is necessary for measuring the characteristic of the wedge prism 20.

The conceptual construction of the reference light source unit 53 is shown in FIG. 5.

15       An X-axis measuring light source 54, slit plate 55, collimator lens 56, beam splitter 57 and camera 51 are arranged on the optical axis of the photographing lens of the camera. Likewise, in the Y-axis direction perpendicular to the X-axis direction on the optical axis which is branched by the beam splitter 57, a  
20       Y-axis measuring light source 58, slit plate 59 and collimator lens 60 are arranged.

25       A slit 61 which is perpendicular to the X axis is formed in the slit plate 55 disposed near the X-axis measuring light source 54 in the X-axis direction at the time of measurement by use of the reference light source unit 53 thus constructed, a light beam passing through the slit 61 is converted to parallel light by

the collimator lens 56 and is made incident on the beam splitter 57. The light beam passing through the beam splitter 57 is made incident on photographing lens of the camera 51.

5           In the Y-axis direction, a slit 62 which is perpendicular to the Y axis is formed in the slit plate 59 disposed near the Y-axis measuring light source 58. A light beam passing through the slit 62 is converted to parallel light by the collimator lens 60 and is made  
10          incident on the beam splitter 57. The incident light beam is bent by 90 degrees by a half mirror in the beam splitter 57 so as to be directed towards the photographing lens and is made incident on the photographing lens of the camera 51.

15           The X-axis measuring light source 54 is controlled to be turned ON/OFF based on an output of the X-axis timing signal output terminal 38. Likewise, the Y-axis measuring light source 58 is controlled to be turned ON/OFF based on an output of the Y-axis timing signal  
20          output terminal 39.

          Further, as a method which does not use the reference light source unit, a method using a chart 63 shown in FIG. 6 can be considered. The black chart 63 is disposed at a distance which is set within a focus  
25          adjustable range of the camera 51. Then, the chart 63 is so positioned that a white slit mark 64 formed in the horizontal direction on the chart 63 will be set

at the center of the photographing area when a control signal is output from the X-axis timing signal output terminal 38.

On the other hand, when a control signal is output from the Y-axis timing signal output terminal 39, the chart 63 is so positioned that a white slit mark 65 formed in the vertical direction on the chart 63 will be set at the center of the photographing area of the camera.

If the measurement is made by the method using the above chart, the same result of measurement as in a case using the reference light source unit can be obtained.

Next, the sub-routine "measurement of wedge prism characteristic" is explained with reference to the flowcharts shown in FIGS. 7A and 7B.

In the step S2 of FIG. 3, if it is detected that the test terminal 37 is short-circuited, the sub-routine "measurement of wedge prism characteristic" is executed.

First, after a timing signal is output from the X-axis timing signal output terminal 38 and the X-axis measuring light source 54 of the reference light source unit 53 is turned ON (step S31), the count of the measurement number counter (Nx) is cleared ("0") (step S32).

Then, in order to apply a voltage determined by

multiplying a value (Nx) of the counter by a measurement voltage ( $\Delta V_x$ ) to the X-axis wedge prism 20a, the output of the D/A converter 44 of the X-axis wedge prism driving circuit 21a is set (step S33).

5           The CPU 4 issues an instruction to the DSP 36 to start the integrating operation of the image sensing device 27 (step S34). In response to the instruction, the DSP 36 starts the integrating operation of the image sensing device 27. Then, the image-sensing  
10           operation is continued for a preset period of time (step S35). The preset period of time is determined by the brightness of light which is made incident on the camera 51 from the reference light source unit 53.

          Next, the CPU 4 issues an instruction to the DSP  
15           36 to fetch image data (step S36). The DSP 36 interrupts the integrating operation of the image sensing device 27, fetches image data, and stores the same into the DRAM 32. The CPU 4 receives only pixel data of an area X necessary for the measurement  
20           operation among the image data stored in the DRAM 32 from the DSP 36 (step S37).

          The position of the pixel data of the area X is shown in FIG. 8. X and Y axes are set on the image sensing device 27 for convenience and it is supposed  
25           that an area along the X axis is set as the area X. Likewise, an area Y is defined in the same manner. Pixel data in the area Y is used when the

characteristic of the Y-axis wedge prism 20b is measured.

As shown in FIG. 9A, a projection pattern passing through the slit is formed on the image sensing device when the X-axis measuring light source is lit. FIG. 9B shows the state in which image data of the area X is plotted.

The center of gravity ( $G_x$ ) of a portion indicated by a mark  $\times$  in FIG. 9B on the X axis is calculated (step S38) and a deflection angle ( $\theta_x$ ) of the light beam by the X-axis wedge prism can be derived by multiplying the center of gravity  $G_x$  by a preset coefficient (step S39).

They are temporarily stored into a memory in the CPU 4 with the deflection angle ( $\theta_x$ ) of the light beam set to correspond to the application voltage ( $\Delta V_x \cdot N_x$ ).

Then, the count of the measurement number counter ( $N_x$ ) is incremented (+1) (step S41) and whether or not the count reaches a preset number ( $N_{x0}$ ) is determined (step S42). If the result of the above determination indicates that the count does not reach the preset number  $N_{x0}$  (NO), the step S33 is effected and the measuring operation is continued. If the count reaches the preset number (YES), the output of the X-axis timing signal is interrupted (step S43) and the X-axis measuring light source 54 is turned OFF.

Next, temperature data of the camera is input

from the temperature measuring circuit 7 to the CPU 4 (step S44).

By the process of the steps S33 to S42, a data table as shown in the table 2 is formed in the memory in the CPU 4 (step S45). The data table indicates the relation between the voltage and the deflection angle of the light beam with the application voltage used as a variable. However, in the EEPROM 19, the relation between the deflection angle and the application voltage is stored as shown in the table 1 with the deflection angle of the light beam used as a variable.

Table 2

Application voltage $\Delta V_x \cdot N_x$	Deflection angle $\theta_x$
1.0 (V)	+1.2
2.0	+0.8
3.0	+0.4
4.0	0.0
5.0	-0.4
6.0	-0.8
7.0	-1.2
8.0	-1.4

The data table of configuration shown in the table 1 is derived based on the data table of the table 2.

For example, if the temperature indicates 20 degrees, it indicates that the data table corresponding to a portion indicated by ※1 in the table 1 is derived. Derived data is stored into an address of the EEPROM 19 corresponding to ※1 in the table 1.

In order to precisely derive the data table,

a variation amount ( $\Delta V_x$ ) of the application voltage is set smaller and the measurement number ( $N_{x0}$ ) is set larger. The optimum values of the variation amount  $\Delta V_x$ , the preset number  $N_{x0}$  of the measurement number  
5 counter are determined by the characteristic of a material constituting the wedge prism 20 and the required precision of the anti-vibration characteristic.

Therefore, it is desirable to adequately change  
10 them rather than to set them to previously determined fixed values. If parameters stored into the EEPROM 19 are used as the variation amount  $\Delta V_x$  and the preset number  $N_{x0}$ , they can be adequately changed as required and it is convenient.

15 In order to form the data table shown in the table 1, it is necessary to make three measurements while changing the temperature. If the characteristic of the material constituting the wedge prism changes in a complicated manner with a change in the temperature,  
20 it is necessary to increase the number of data tables. If a change in the characteristic with the temperature change monotonically increases or decreases, the table can be formed by use of data measured at a representative temperature. For example, only a data table for  
25 the temperature of 20 degrees is formed and stored into the EEPROM. Then, the value of the data table is corrected and used based on a difference between the



temperature of the camera and 20 degrees when the shake correcting operation is effected.

When the measurement of the X-axis wedge prism 20a is completed, the characteristic measuring operation of the Y-axis wedge prism 20b is effected.

After this, in the characteristic measurement of the Y-axis wedge prism 20b effected in the steps S47 to S62, the Y-axis measuring light source 58 is turned ON, the same operations and calculation processes as those in the measurement of the X-axis wedge prism 20a are effected, and a data table formed is stored into the EEPROM 19. Thus, since it is clearly understood from the flowchart that the measuring operation is the same as the measuring operation in the X-axis wedge prism, the explanation therefor is omitted.

In the above embodiment, the calculation process is effected on the camera side, but it is possible to output image data to the external control device (PC) 33 via the communication interface circuit 34 and effect the data table forming process on the PC 33 side. This is an effective method for reducing the number of manufacturing steps, for example, in a case where the operation for forming the data table is a heavy load and it takes a long time to effect the calculation process for the CPU 4 of the camera.

FIG. 10 shows an example of the schematic construction of a silver halide film camera containing

a shake correction device according to a second embodiment of this invention.

5 Portions shown in FIG. 10 which are the same as those of the first embodiment shown in FIG. 1 are denoted by the same reference numerals and the explanation therefor is omitted.

10 The camera of this embodiment includes an optical finder 78 and a photographing lens 11, lens shutter 71 and aperture 72 are disposed behind a wedge prism 20. A film 73 is loaded into the camera via the aperture 72.

15 The lens shutter 71 is used instead of the diaphragm 14 of the first embodiment and a sector provided on the lens shutter 71 is driven by a lens shutter driving mechanism 74 having an actuator. Power required for driving the actuator is supplied from a lens shutter driving circuit 75 controlled by a CPU 4. Therefore, the lens shutter driving circuit 75 can be controlled by the CPU 4 so that the film 73  
20 can be exposed for a time.

Further, feeding of the film 73 is effected by a film driving mechanism 76 having an actuator such as a motor and the film driving mechanism 76 is supplied with a driving power supply voltage from a film driving  
25 circuit 77 controlled by the CPU 4 so as to wind up or rewind the film 73 as required.

An image sensing unit 79 surrounded by broken

lines shown in FIG. 10 is mounted on the camera instead of the film 73 only at the time of characteristic measurement of the wedge prism 20.

5 This is because the camera of this embodiment does not have an image sensing device and the characteristic measurement cannot be made by using the image sensing device as in the first embodiment, and therefore, the image sensing unit 79 is mounted instead of the film 73 at the time of measurement. The image sensing unit 79  
10 includes an image sensing device 80 formed of a CCD and an image sensing device controlling circuit 81 which is controlled by an external control device 33 such as a personal computer, for driving the image sensing device 80. Further, at the time of characteristic  
15 measurement, a reference light source unit 53 which is the same as that described before is used.

With the above construction, the image sensing device 80 of the image sensing unit 79 is controlled based on an instruction from the external control  
20 device 33 and the CPU 4 is operated based on an instruction supplied from the external control device 33 via a communication interface 34 during the measurement operation.

The main operation of the camera of the second  
25 embodiment is explained with reference to the flowcharts shown in FIGS. 11A and 11B.

First, if the power switch 5 is turned ON,

the power supply voltage is supplied to the system of the camera and the CPU 4 starts the operation to effect the initialization process for the I/O port, memory and other circuits (step S71).

5           Then, whether or not a communication request from the external control device 33 is present or not is determined based on an output of the communication interface circuit 34 (step S72). If the result of the above determination indicates that there is no  
10           communication request (NO), a normal operation mode is determined and present temperature data of the camera measured by the temperature measuring circuit 7 is input (step S73).

          Then, the same process as that of the steps S5 to  
15           S7 is effected, and voltage data is read out from the data table of the EEPROM 19 and input to the CPU 4 (step S74). In order to apply the centering voltages from the data table of the table 1 to the X-axis, Y-axis wedge prisms 20a, 20b, outputs of D/A converters  
20           44 of X-axis, Y-axis prism driving circuits 21a, 21b are set (step S75). The centering operation is effected based on the temperature data and voltage data of the camera. The operations of the temperature measurement, the voltage readout of the wedge prism  
25           and the application of the centering voltage are periodically effected.

          Then, luminance data of the subject is input from

a photometry circuit 8 and the exposure, that is, the shutter period is calculated (step S76).

5           Next, whether the release switch 6 is set in the OFF state or not is determined (step S77) and if it is set in the OFF state, the ON/OFF state of the power switch 5 is detected (step S78). If the power switch 5 is set in the ON state, the process returns to the step S73 and the CPU 4 continues the operation. However, if it is set in the OFF state, the system interruption process is effected (step S79) and the operation of the CPU 4 is interrupted.

10

          If it is detected in the step S77 that the release switch 6 is set in the ON state, the X-axis, Y-axis integrating circuits 23a, 23b are initialized (step S80).

15

          Next, the lens shutter 71 is opened (step S81) to start the exposing operation and start the counting operation of the timer counter for counting the shutter period set in the step S7 (step S82).

20

          Then, whether or not the count time of the timer counter reaches the set shutter period is determined (step S83).

          If the result of the above determination indicates that it does not reach the shutter period (NO), the same shake correcting process as the process of the steps S21 to S26 shown in FIG. 3 is effected.

25

          First, a shake amount in the X-axis direction

(camera deflection angle) is measured (step S86).  
A voltage applied to the X-axis wedge prism 20a is  
derived (step S87) based on the derived camera  
deflection angle and table data. The D/A converter 44  
5 of the X-axis wedge prism driving circuit 23a is set so  
as to apply the application voltage to the X-axis wedge  
prism 20a (step S88).

Likewise, in the case of shake in the Y-axis  
direction, the deflection angle of the camera is  
10 derived and a voltage applied to the Y-axis wedge  
prism 20b is derived to set the D/A converter 44 of  
the Y-axis wedge prism driving circuit 23b (steps S89  
to S91).

After the setting, the process returns to the  
15 step S83. During the exposing operation, the shake  
correction operation of the steps S86 to S91 is  
repeatedly effected at high speed and the subject image  
formed on the film is fixed irrespective of the shake.

Then, in the step S83, after a preset shutter  
20 period has elapsed (YES), the lens shutter 71 is closed  
(step S84), the film 73 is wound up by one frame (step  
S85), the process returns to the step S73 and the same  
process is repeatedly effected.

If it is detected in the step S72 that a  
25 communication request is issued from the external  
control device 33 which will be described later (YES),  
the lens shutter 71 is opened (step S92) and the

sub-routine "external control mode" is executed (step S93). After the operation of the sub-routine is completed, the lens shutter 71 is closed (S94).

5 In the above operation, since it is necessary to apply light required for measurement to the camera from the reference light source unit 53 to measure the characteristic of the wedge prism 20, the lens shutter 71 which is normally closed for light shielding is set into the open state. For this purpose, the lens shutter 71 is opened in the step S92, and after the measurement by the external control mode is terminated, the lens shutter 71 is closed.

10 The external control mode shown in the step S93 of FIG. 11A is explained with reference to the flowchart shown in FIG. 12.

15 First, command data is input from the external control device 33 via the communication interface circuit 34 (step S101). Whether the command data indicates application of a voltage to the X-axis wedge prism 20a or not is determined (step S102).

20 If the result of the above determination indicates the voltage application (YES), voltage data ( $V_x$ ) indicating an application voltage is input from the external control device 33 (step S103). The voltage data  $V_x$  is set in the D/A converter 44 of the X-axis wedge prism driving circuit 21a. Then, in order to receive a next command, the process returns to the step

S101 and the process for the next input command is effected.

5           If it is detected in the step S102 that the input command data does not indicate the voltage application to the X-axis wedge prism 20a (NO), whether the command data indicates application of a voltage to the Y-axis wedge prism 20b or not is determined (step S105).

10           If the result of the above determination indicates the voltage application to the Y-axis wedge prism 20b (YES), voltage data (Vy) indicating an application voltage is input from the external control device 33 (step S106).

15           The voltage data Vy is set in the D/A converter 44 of the Y-axis wedge prism driving circuit 21b (step S107), and then, the process returns to the step S101.

20           If it is detected in the step S105 that the input command data does not indicate the voltage application to the Y-axis wedge prism 20b (NO), whether the command data indicates storage of data into the EEPROM 19 or not is determined (step S108). If the result of the above determination indicates storage of data into the EEPROM 19 (YES), the CPU 4 fetches table data from the external control device 33 via the communication interface circuit 34 (step S109). Further, the table data is stored into the EEPROM 19 (step S110).

25

          Then, in order to receive a next command, the process returns to the step S101 and the process for



the next input command is effected.

If it is detected in the step S108 that the input command data does not indicate storage of data into the EEPROM 19 (NO), whether the command data indicates  
5 termination of the external control or not is determined (step S111). If the result of the above determination indicates termination of the external control (YES), the process returns to the main routine to terminate the sub-routine. If the command data does  
10 not indicate termination of the external control (NO), the process returns to the step S101 to receive next command data.

Next, a program executed on the external control device when the prism characteristic is measured,  
15 a data table necessary for control of the wedge prism is formed and the data table is stored into the EEPROM of the camera is explained with reference to the flowcharts shown in FIGS. 13A and 13B.

First, a communication request is issued from the  
20 external control device 33 to the camera (step S121). The communication request is detected in the step S72 shown in FIG. 11. The CPU 4 of the camera executes the sub-routine "external control mode" explained with reference to FIG. 12.

25 Next, the X-axis measuring light source 54 in the reference light source unit 53 is lit (step S122). After the light source is lit, parameters ( $\Delta V_x$ ,  $N_x$ ,

$\Delta V_y$ ,  $N_y$ ) indicating the measurement condition are input to the external control device 33 (step S123). The inputting operation is effected by an operator of the manufacturing line for effecting the measurement operation or an operator of the repair center.

After the measurement number counter ( $N_x$ ) is cleared (step S124), a command indicating the X-axis voltage application is transferred to the CPU 4 (step S125). The count ( $N_x$ ) of the counter is multiplied by the voltage  $\Delta V_x$  which is one of the measurement parameters to determine a voltage applied to the wedge prism 20 and voltage data thereof is transferred to the CPU 4 (step S126).

The CPU 4 of the camera applies a voltage to the X-axis wedge prism 20a based on the transferred command indicating the X-axis voltage application and voltage data applied to the x-axis wedge prism 20a and then controls the image sensing unit 79 to cause the external control device 33 to fetch image data (step S127) and takes out data of the area X from the image data (step S128).

In the first embodiment, the area X is an area on the CCD of the image sensing unit 79 having the same significance as the area X shown in FIG. 8. The center of gravity ( $G_x$ ) of image data of the area X is derived in the same manner as in the step S38 of FIG. 7 (step S129). A deflection angle ( $\theta_x$ ) of the light beam

obtained by the X-axis wedge prism is derived by multiplying the thus derived center of gravity  $G_x$  by a preset coefficient (step S130). They are temporarily stored into a memory of the external control device 33 with the deflection angle  $\theta_x$  of the light beam and the application voltage ( $\Delta V_x \cdot N_x$ ) set to correspond to each other (step S131).

After this, the measurement number counter ( $N_x$ ) is incremented (+1) (step S132) and whether or not the count reaches a preset number ( $N_{xo}$ ) which is one of the parameters indicating the measurement condition is determined (step S133). If the result of the above determination does not indicate that the count reaches the preset number  $N_{xo}$  (NO), the process returns to the step S125 and the measurement operation is continued. If the result of the above determination indicates that the count reaches the preset number  $N_{xo}$  (YES), generation of the X-axis timing signal is interrupted and then the X-axis measurement light source 54 is turned OFF (step S134).

Next, table data which will be used for the succeeding control of the wedge prism is formed based on the relation between the application voltage ( $\Delta V_x \cdot N_x$ ) and the deflection angle  $\theta_x$  of the light beam derived in the processing operation in the steps S124 to S133 (step S135). After formation of the table data, an EEPROM write command is transferred to the CPU

4 (step S136). The formed table data is transferred to the CPU 4 (step S137). The CPU 4 which has received the command and table data stores the table data into the EEPROM 19 in the step S110 of FIG. 12.

5 By the above measurement and operation, the table data indicating the relation between the voltage data applied to the X-axis wedge prism 20a and the deflection angle  $\theta_x$  of the light beam is derived. Next, the characteristic of the Y-axis wedge prism 20b is measured and table data is formed. In the table forming operation, the process equivalent to that for the X-axis wedge prism 20a is effected and therefore the detail explanation therefor is omitted.

10 In the Y-axis wedge prism 20b, the process equivalent to the process of the steps S122 to S137 is effected to from table data of the Y-axis wedge prism 20b and store the same into the EEPROM 19.

15 Then, after the respective table data items of the X-axis wedge prism 20a and Y-axis wedge prism 20b are stored into the EEPROM 19, an external control termination command is transferred to the CPU 4 from the external control device 33. The CPU 4 which has received the above command terminates the operation of the sub-routine "external control mode" shown in  
20 FIG. 12.  
25

FIG. 14 shows an example of the schematic construction of a shake correction device mounted on

an optical device other than a camera, for example,  
an optical device such as a telescope or binocular as  
a third embodiment of this invention. Constituents in  
this embodiment which are equivalent to those of the  
5 first and second embodiments are denoted by the same  
reference numerals and the explanation therefor is  
omitted.

The lens system of the optical device includes  
a wedge lens 20 for shake correction, objective 82,  
10 erect prism 83 and eyepiece 84.

With the above construction, a subject image  
formed by the objective 82 is magnified by the eyepiece  
84 and is made incident on the eyes of an observer (not  
shown). In this case, the erect prism 83 is disposed  
15 between the objective 82 and the eyepiece 84 to  
constitute an afocal system for making erect the  
subject image formed by the objective 82.

Since the optical system of this embodiment is a  
focal system, the light beam emitted from the eyepiece  
20 84 is parallel. Therefore, even if the image sensing  
unit 79 used in the second embodiment is disposed  
behind the eyepiece 84, no image is formed on the light  
receiving surface of a CCD 80.

Therefore, an image sensing unit 85 used in this  
25 embodiment has a collimator lens 86 disposed between  
the eyepiece 84 and the CCD 80 so as to re-form an  
image on the CCD 80 by focusing the light beam emitted

from the eyepiece 84.

After this, like the second embodiment, the operation for measuring the characteristic of the wedge prism 20 is effected by use of the light beam focused on the light receiving surface of the CCD 80.

Other than the wedge prism 20 used in the above embodiments, it is also possible to use a variable apex angle prism which is formed by sealing a liquid having an index of refraction into a space between two glass plates and which can change the direction of a light beam passing therethrough by changing the angle made by the two glass plates by use of an actuator. As the actuator, a voice coil or the like can be used.

Measurement of the characteristic of the prism can be made by use of the method for measuring the characteristic of the prism of the above embodiment.

The technology for measuring the characteristic of the anti-vibration (vibration preventing) optical system according to the embodiment described before can be applied not only to the wedge prism but also to an optical device for shifting or tilting part of the conventional photographing lens to attain the anti-vibration operation on the manufacturing line or the product checking line.

As described above, the reference light source unit used in the above embodiments requires two light sources including the X-axis measurement light source

and Y-axis measurement light source. However, measurement of the characteristic of the wedge prism can be made by use of only one spot light source.

For example, FIG. 15 shows a modification for  
5 measuring the wedge prism characteristic and a shake correction wedge prism 92 is disposed along the optical axis of a photographing lens 91 and spot light 94 is made incident on an image sensing device 95 from a light source 93. As the light source 93, a laser may  
10 be used. The spot light 94 from the light source 93 forms a pattern as shown in FIG. 16 on the image sensing device 95.

By deriving the coordinate position ( $G_x$ ,  $G_y$ ) of the center of gravity of the pattern, the relation  
15 between the voltage and the deflection angle is made clear as already explained. However, even if image data (areas X, Y) only in specified areas as shown in FIG. 8 is used, the coordinate position of the center of gravity cannot be attained.

20 This is because the state of the Y-axis prism is indefinite when the characteristic of the X-axis prism is measured. Therefore, a projection pattern does not always exist on the area X. As a result, it is necessary to read out all of the image data and obtain  
25 the coordinate position of the projection pattern. This indicates that the operation for deriving the coordinate position becomes complicated.

The CCD image sensor is used as the sensor for measuring the coordinates of the projection pattern in the image sensing unit used in the above embodiments, but it is also possible to use a 2-dimensional PSD  
5 (a device for detecting the position of a light spot).

As described above in detail, according to this invention, it is possible to provide a shake correction device in which parameters indicating the relation between the deflection angle of a light beam and  
10 application voltages to the wedge prisms used in the shake correction device mounted on the optical device such as the camera are derived and stored and a shake correction amount based on a shake amount detected at the time of shake correction is corrected according to  
15 the parameters to effect the adequate shake correction operation.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to  
20 the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.



**DISCOUNTS**

- DISCOUNTS**

section by use of said image sensing device.

2. The shake correction device according to claim 1, wherein said shake detecting section includes a first shake angle detecting section for detecting a shake angle in a first axial direction and a second shake angle detecting section for detecting a shake angle in a second axial direction perpendicular to the first axial direction.

3. The shake correction device according to claim 2, wherein said prism portion includes a first prism for changing the angle of the light beam passing therethrough in the first axial direction and a second prism for changing the angle of the light beam passing therethrough in the second axial direction.

4. The shake correction device according to claim 3, wherein said first prism changes the light beam in a direction to cancel the shake angle detected by said first shake angle detecting section.

5. The shake correction device according to claim 3, wherein said second prism changes the light beam in a direction to cancel the shake angle detected by said second shake angle detecting section.

6. The shake correction device according to claim 1, further comprising a temperature measuring circuit for measuring a temperature of said prism portion.

7. The shake correction device according to

claim 6, further comprising a table data forming  
circuit for forming table data obtained by adding  
temperatures measured by said temperature measuring  
circuit to the relation between the voltage applied to  
5 said prism portion and the deflection angle of the  
light beam passing through said prism portion.

8. The shake correction device according to  
claim 1, wherein said shake detecting section detects  
a shake state occurring in an electronic still camera.

10 9. The shake correction device according to  
claim 1, wherein said shake detecting section detects  
a shake state occurring in a film camera.

10. An electronic still camera comprising:  
an image sensing device for converting a subject  
15 image to image data;  
a shake detecting section including a first shake  
angle detecting section for detecting a shake angle  
in a first axial direction and a second shake angle  
detecting section for detecting a shake angle in  
20 a second axial direction perpendicular to the first  
axial direction;

a prism portion for changing an angle of a light  
beam passing therethrough according to a voltage  
applied thereto;

25 a temperature measuring circuit for measuring  
a temperature of said prism portion;

an application voltage generating section for

generating a voltage applied to said prism portion;

5 a storage section for storing the relation between the voltage applied to said prism portion, the deflection angle of a light beam passing through said prism portion and the temperature of said prism portion;

10 a control section for determining a voltage to be applied to said prism portion based on an output of said shake detecting section and an output of said storage section and controlling said voltage generating section to generate the thus determined application voltage; and

15 a setting section for selectively setting one of an image sensing mode for image-sensing the subject image and a test mode for measuring the relation between the voltage applied to said prism portion and the deflection angle of the light beam passing through said prism portion which is stored in said storage section by use of said image sensing device.

20 11. The electronic still camera according to claim 10, wherein said temperature measuring circuit measures the temperature of said prism portion prior to the shake correcting operation by said prism portion.

25 12. The electronic still camera according to claim 11, further comprising an application voltage determining circuit for determining voltages to be applied to said first and second prisms by referring to

the application voltage and shake angle stored in said storage section based on the temperature measured by said temperature measuring circuit.

13. The electronic still camera according to  
5 claim 12, wherein said application voltage determining circuit determines a first application voltage (centering voltage) which prevents said prism portion from changing the angle of the light beam passing therethrough.

10 14. The electronic still camera according to claim 13, wherein said application voltage generating section generates a first application voltage determined by said application voltage determining circuit.

15 15. The electronic still camera according to claim 12, wherein said application voltage determining circuit determines a second application voltage which permits said prism portion to change the angle of the light beam passing therethrough.

20 16. The electronic still camera according to claim 15, wherein said application voltage generating section generates a second application voltage determined by said application voltage determining circuit.

25 17. The electronic still camera according to claim 16, wherein said application voltage generating section is operated from the start of the image-sensing

operation of said image sensing device to time when a preset shutter period is reached.

18. The electronic still camera according to claim 10, wherein said prism portion includes a first prism for changing the angle of the light beam passing therethrough in the first axial direction and a second prism for changing the angle of the light beam passing therethrough in the second axial direction.

19. The electronic still camera according to claim 18, wherein said first prism changes the light beam in a direction to cancel the shake angle detected by said first shake angle detecting section.

20. The electronic still camera according to claim 18, wherein said second prism changes the light beam in a direction to cancel the shake angle detected by said second shake angle detecting section.

21. A film camera comprising:

a shake detecting section including a first shake angle detecting section for detecting a shake angle in a first axial direction and a second shake angle detecting section for detecting a shake angle in a second axial direction perpendicular to the first axial direction;

a prism portion for changing an angle of a light beam passing therethrough according to a voltage applied thereto;

a temperature measuring circuit for measuring

a temperature of said prism portion;

an application voltage generating section for  
generating a voltage applied to said prism portion;

5 a storage section for storing the relation between  
the voltage applied to said prism portion, the  
deflection angle of a light beam passing through said  
prism portion and the temperature of said prism  
portion; and

10 a control section for determining a voltage to be  
applied to said prism portion based on an output of  
said shake detecting section and an output of said  
storage section and controlling said voltage generating  
section to generate the thus determined application  
voltage;

15 wherein one of an image sensing mode for image-  
sensing a subject image and a test mode for measuring  
the relation between the voltage applied to said prism  
portion and the deflection angle of the light beam  
passing through said prism portion which is stored in  
20 said storage section is selectively set by use of an  
external control device provided separately from the  
film camera.

22. The film camera according to claim 21, wherein  
an image sensing unit including an image sensing device  
25 and image sensing device controlling circuit is mounted  
on the film camera at the time of test mode.

23. The film camera according to claim 22, wherein

the test mode is executed by use of said image sensing unit.

24. The film camera according to claim 21, wherein said prism portion includes a first prism for changing  
5 the angle of the light beam passing therethrough in the first axial direction and a second prism for changing the angle of the light beam passing therethrough in the second axial direction.

25. The film camera according to claim 24, wherein  
10 said first prism changes the light beam in a direction to cancel the shake angle detected by said first shake angle detecting section.

26. The film camera according to claim 24, wherein  
15 said second prism changes the light beam in a direction to cancel the shake angle detected by said second shake angle detecting section.

27. An optical device comprising:

a shake detecting section including a first shake  
angle detecting section for detecting a shake angle in  
20 a first axial direction and a second shake angle detecting section for detecting a shake angle in a second axial direction perpendicular to the first axial direction;

a prism portion for changing an angle of a light  
25 beam passing therethrough according to a voltage applied thereto;

an afocal optical system disposed behind said



prism portion;

a collimator lens disposed between said afocal  
optical system and an image sensing device, for forming  
an image on the image sensing device by use of parallel  
5 light emitted from said afocal optical system;

a temperature measuring circuit for measuring  
a temperature of said prism portion;

an application voltage generating section for  
generating a voltage applied to said prism portion;  
10 a storage section for storing the relation between  
the voltage applied to said prism portion, the  
deflection angle of a light beam passing through said  
prism portion and the temperature of said prism  
portion;

15 a control section for determining a voltage to be  
applied to said prism portion based on an output of  
said shake detecting section and an output of said  
storage section and controlling said voltage generating  
section to generate the thus determined application  
20 voltage; and

a setting section for setting a test mode for  
measuring the relation between the voltage applied to  
said prism portion and the deflection angle of the  
light beam passing through said prism portion which is  
25 stored in said storage section by use of said image  
sensing device.

28. The optical device according to claim 27,

wherein said prism portion includes a first prism for changing the angle of the light beam passing therethrough in the first axial direction and a second prism for changing the angle of the light beam passing therethrough in the second axial direction.

29. The optical device according to claim 28, wherein said first prism changes the light beam in a direction to cancel the shake angle detected by said first shake angle detecting section.

30. The optical device according to claim 28, wherein said second prism changes the light beam in a direction to cancel the shake angle detected by said second shake angle detecting section.

31. The optical device according to claim 27, wherein the optical device is a binocular.

32. The optical device according to claim 27, wherein the optical device is a telescope.

33. An optical device comprising:  
an image sensing device for converting a subject image to image data;

a shake detecting section for detecting a shake state;

a prism portion for changing an angle of a light beam passing therethrough according to a voltage applied thereto;

an application voltage generating section for generating a voltage applied to said prism portion;

a storage section for storing the relation between the voltage applied to said prism portion and the deflection angle of the light beam passing through said prism portion;

5 a control section for determining a voltage to be applied to said prism portion based on an output of said shake detecting section and an output of said storage section and controlling said voltage generating section to generate the thus determined application  
10 voltage; and

a setting section for selectively setting one of an image sensing mode for image-sensing the subject image by use of said image sensing device and a test mode for measuring the relation between the voltage  
15 applied to said prism portion and the deflection angle of the light beam passing through said prism portion which is stored in said storage section by use of said image sensing device.

34. A shake correction method in an optical device  
20 having a prism portion for changing an angle of a light beam passing therethrough according to a voltage applied thereto, comprising:

a shake detecting step of detecting a shake state;  
an application voltage determining step of  
25 determining a voltage to be applied to the prism portion based on shake information detected by said shake detecting step;

a voltage applying step of applying an application voltage determined by said application voltage determining step to the prism portion;

5 a shake correcting step of effecting a shake correcting process by use of the prism portion in response to application of the voltage in said voltage application step; and

10 a data forming step of forming data indicating the relation between the voltage applied to the prism portion and the shake amount which is referred to in said application voltage determining step.

ABSTRACT OF THE DISCLOSURE

A camera of this invention is a camera containing  
a shake correction device for correcting the shake by  
reading out application voltage data corresponding to  
5 a detected shake amount by use of parameters stored in  
an EEPROM indicating the relation between a voltage  
applied to a wedge prism and a deflection angle of  
a light beam and applying a voltage subjected to the  
temperature correcting process to the wedge prism to  
10 change the index of refraction of the wedge prism and  
deflect the light beam in a direction opposite to the  
shake direction. The parameters are determined by  
deriving the relation between the application voltage  
and the inclination of the light beam by detecting  
15 the inclination of a reference light beam from the  
illuminating position of the image sensing device while  
changing the index of refraction of the wedge prism by  
applying a voltage to the wedge prism and then stored  
into an EEPROM as a data table

FIG. 1



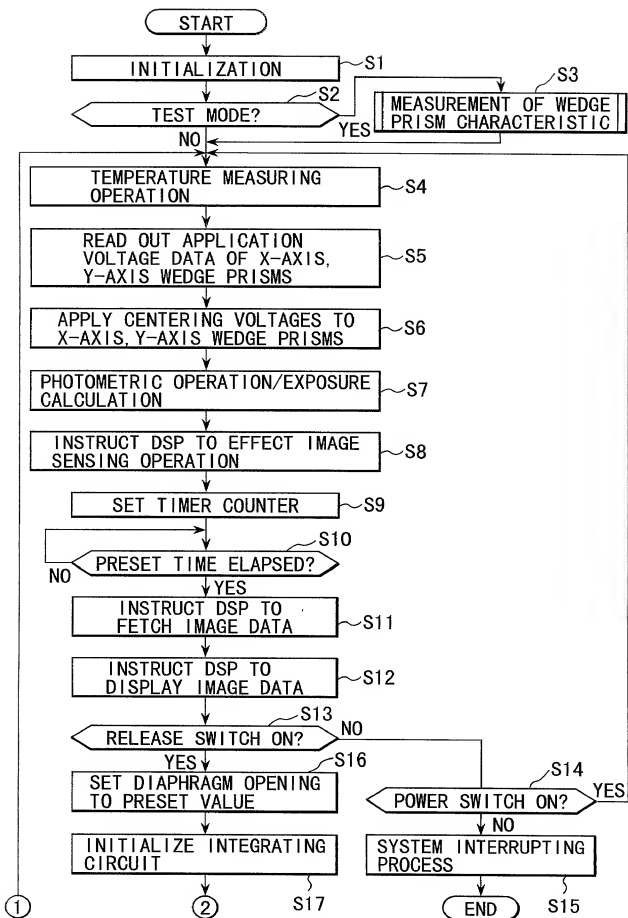


FIG. 3A



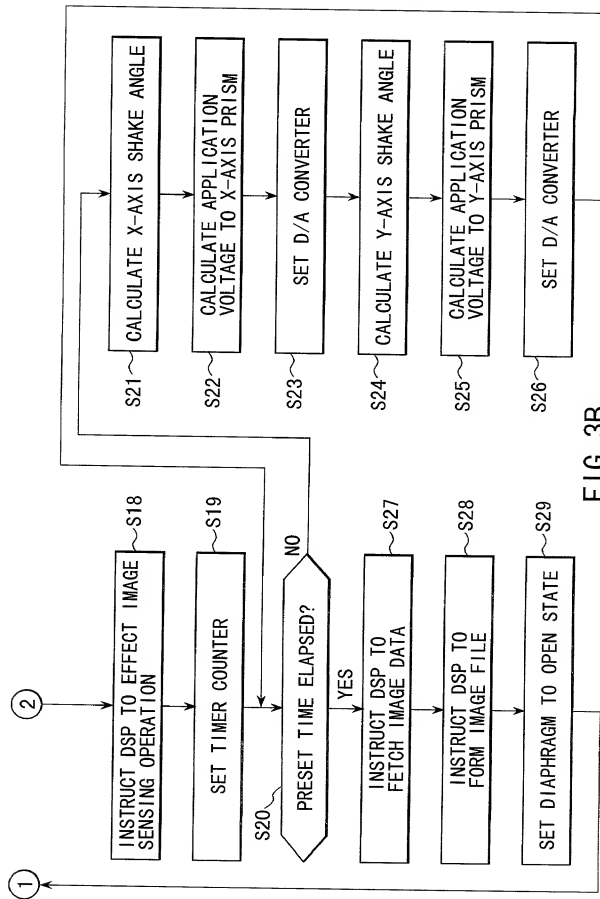


FIG. 3B

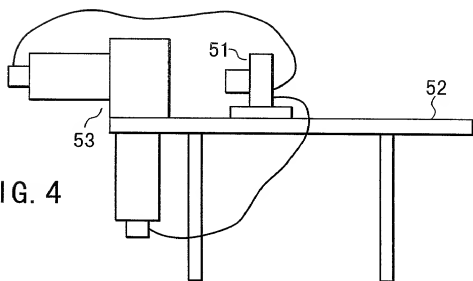


FIG. 4

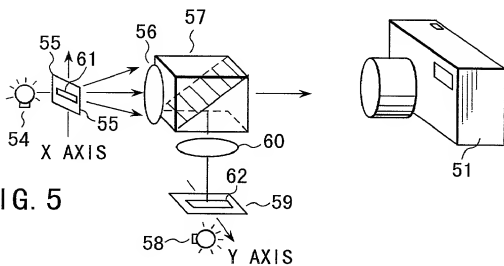


FIG. 5

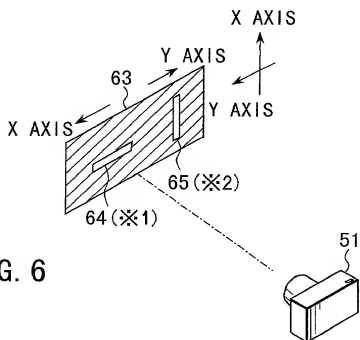


FIG. 6

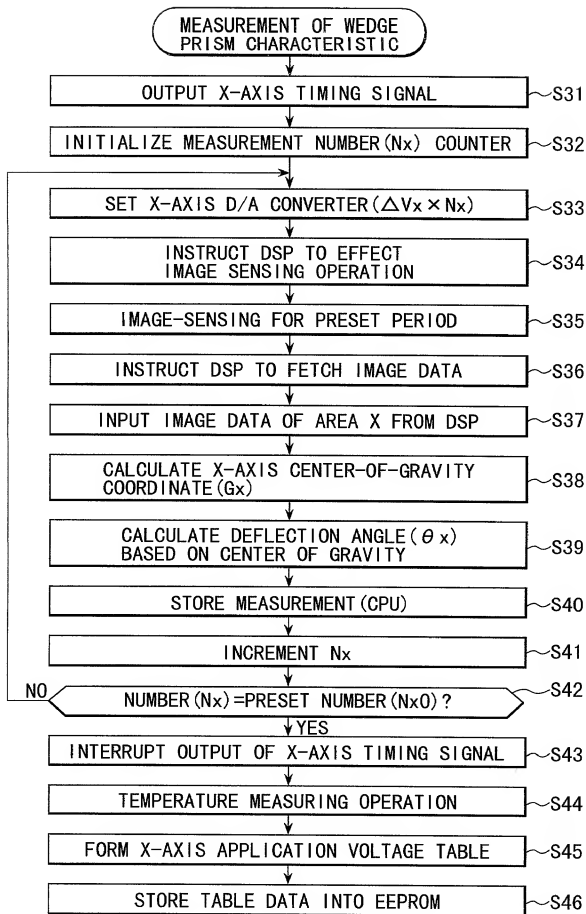
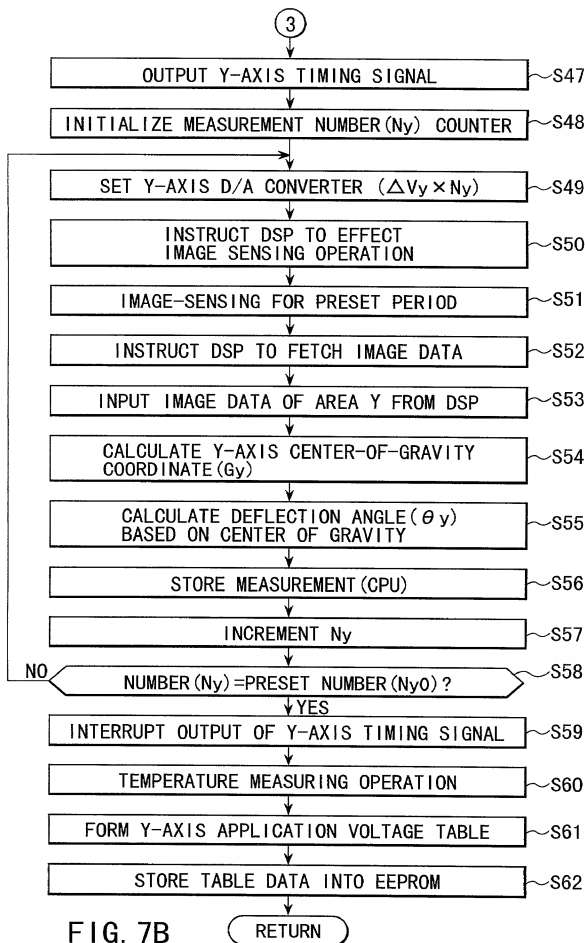


FIG. 7A



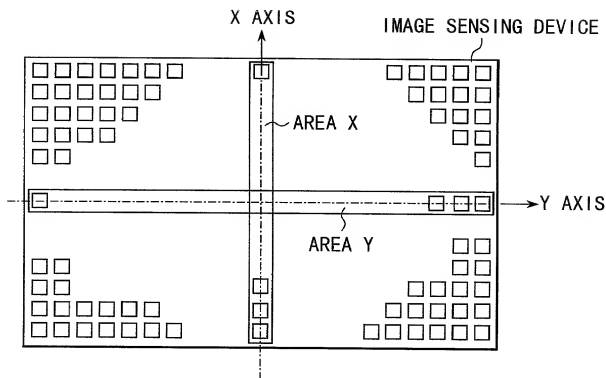


FIG. 8

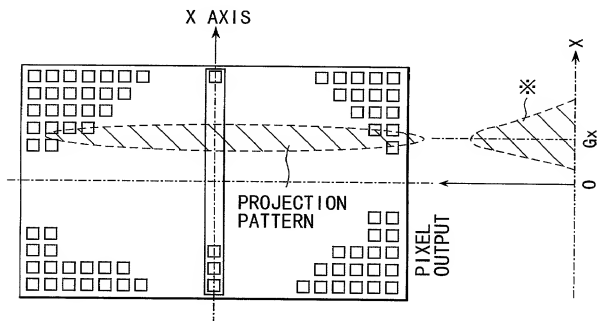


FIG. 9A

FIG. 9B

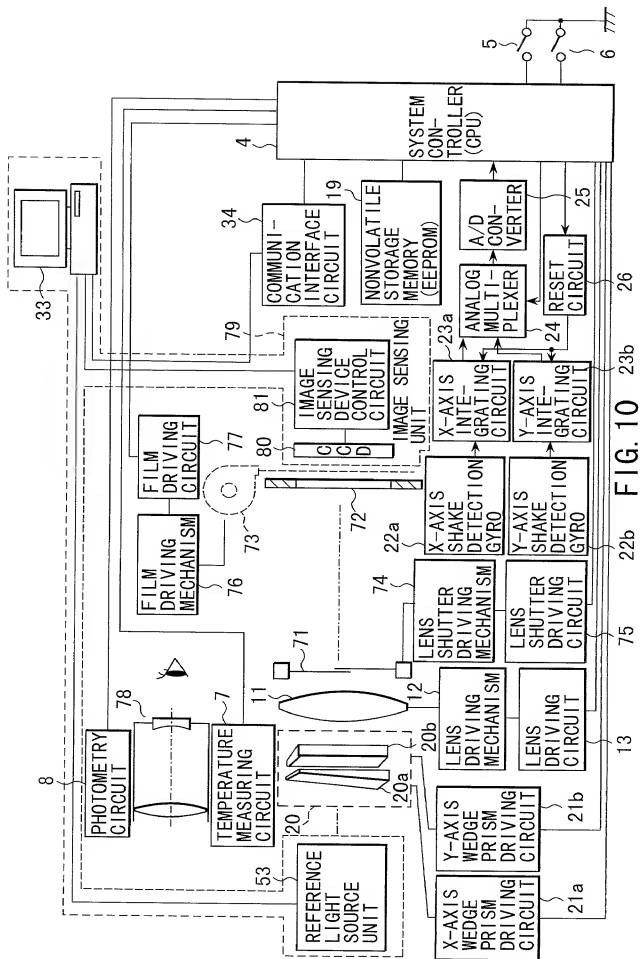


FIG. 10



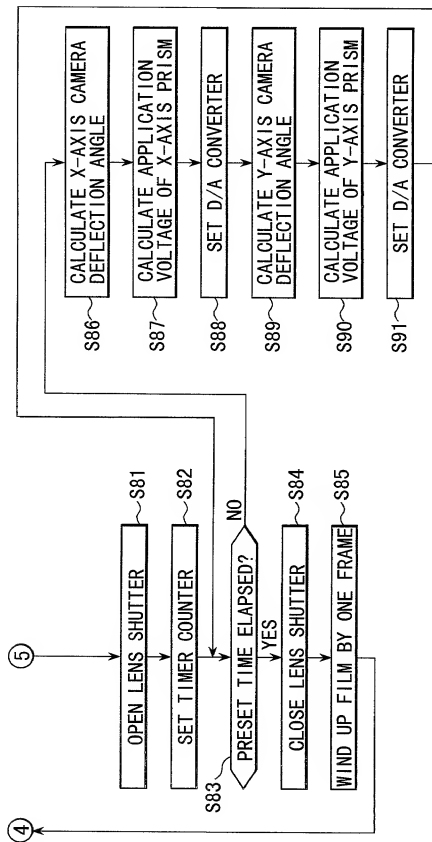


FIG. 11B



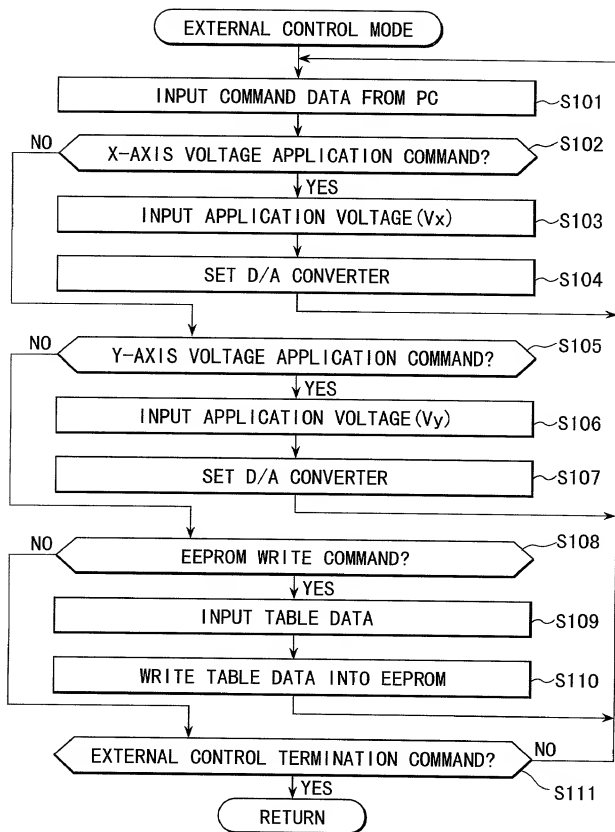


FIG. 12

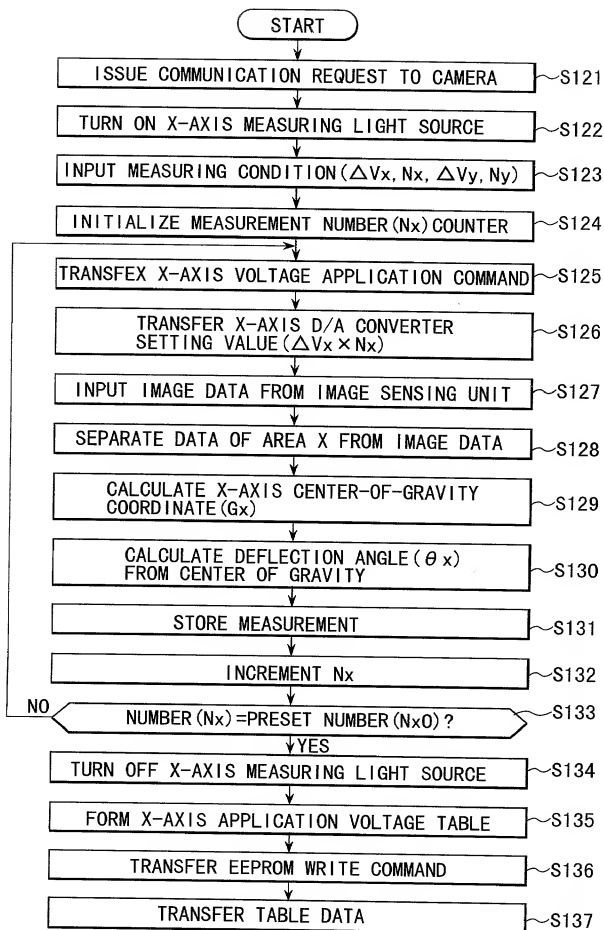
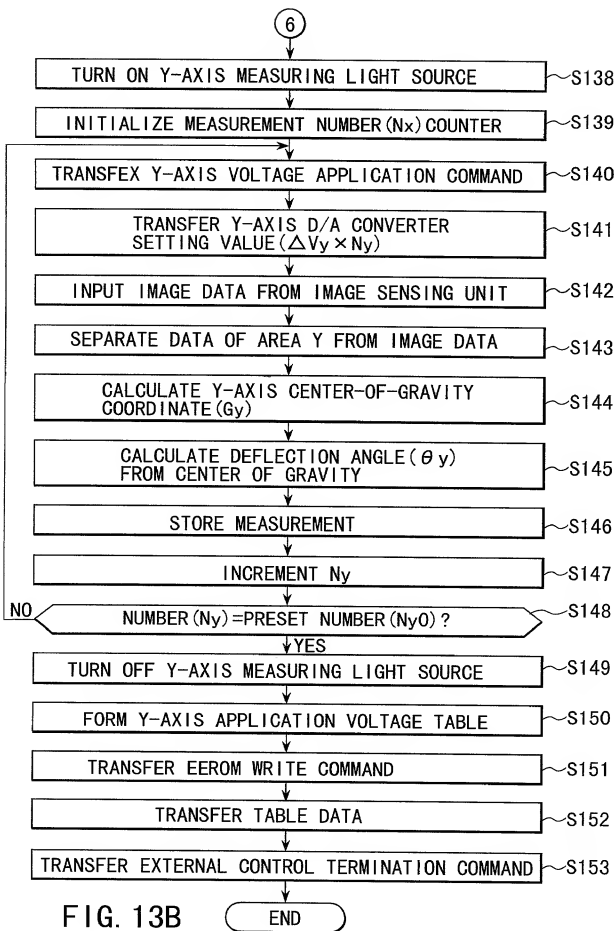
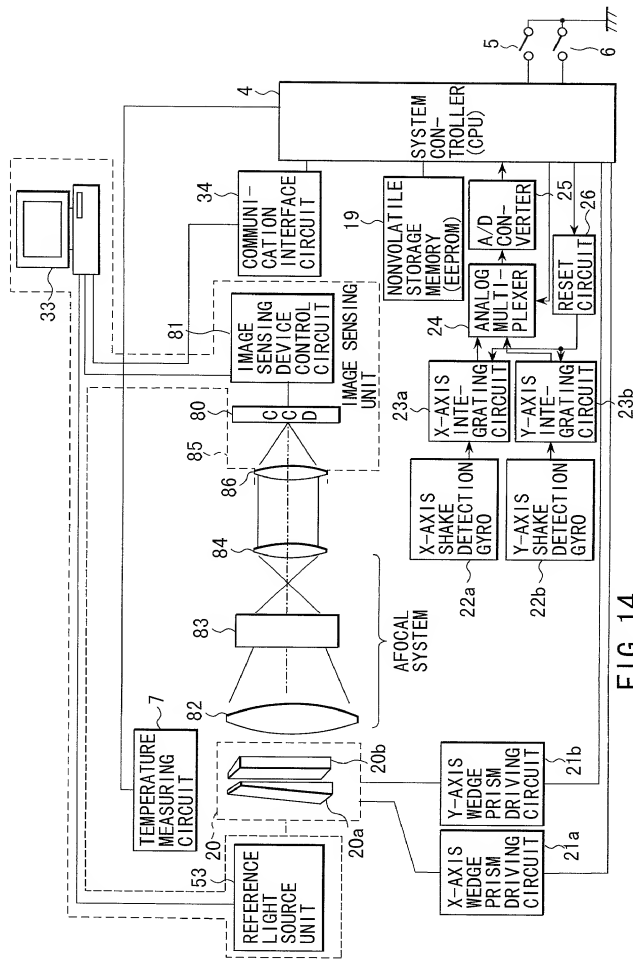


FIG. 13A





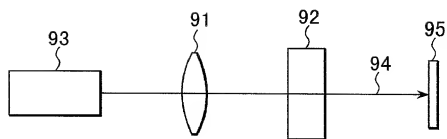


FIG. 15

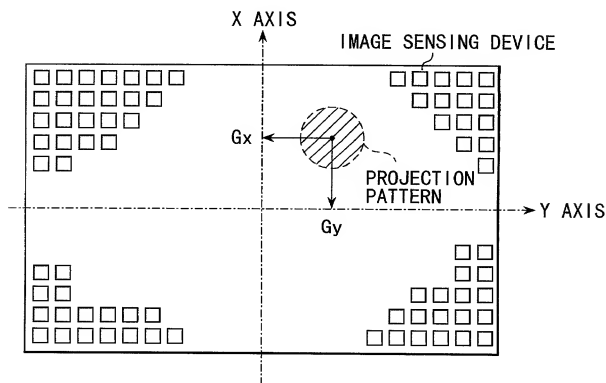


FIG. 16

## Declaration Power of Attorney For Patent Application

## 特許出願宣言書及び委任状

## Japanese Language Declaration

## 日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の横に記載された通りです。

My residence, post office address and citizenship are as stated below next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者である（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

手おれ補正装置を搭載するカメラ

CAMERA HAVING SHAKE CORRECTION  
DEVICE MOUNTED THEREON

上記発明の明細書（下記の欄で×印がついていない場合は、本書に添付）は、

The specification of which is attached hereto unless the following box is checked:

☐ 月 日に  
提出され米国出願番号または特許協定条約

☐ was filed on \_\_\_\_\_  
as United States Application Number or  
PCT International Application Number

国際出願番号を \_\_\_\_\_ とし、  
(該当する場合) 月 日に訂正されました。

\_\_\_\_\_ and was amended on \_\_\_\_\_  
(if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56

0651-0032 (8-98)

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## Japanese Language Declaration

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I hereby claim foreign priority under Title 35, United States Code, Section 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below by checking the box, any foreign application for patent or inventor's certificate, or PCT international application having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)

外国での先行出願

Priority Not Claimed

優先権の主張なし

11-149996

JAPAN

28/05/1999

(Number)  
(番号)(Country)  
(国名)(Day/Month/Year Filed)  
(出願年月日)

私は、第35編米国法典第119条(e)項に基づいて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below

(Application No.)  
(出願番号)(Filing Date)  
(出願日)(Application No.)  
(出願番号)(Filing Date)  
(出願日)

私は、下記の米国法典第35編120条に基づいて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条(c)に基づき権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願を提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1.56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

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(Application No.)  
(出願番号)(Filing Date)  
(出願日)(Status: Patented, Pending, Abandoned)  
(状況: 特許許可済、係属中、放棄済)(Application No.)  
(出願番号)(Filing Date)  
(出願日)(Status: Patented, Pending, Abandoned)  
(状況: 特許許可済、係属中、放棄済)

私は、私自身の知識に基づいて本宣言書中で私が行う表明が真実であり、かつ私の入手した情報と私の信じているところに基づき表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、認罪した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

## Japanese Language Declaration

(日本語宣言書)

委任状：私は、下記の発明者として、本出願に関する一切の手続きを米特許商標局に対して遂行する弁理士または代理人として、下記の者を指名いたします。  
(弁理士、または代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number)

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(第二以降の共同発明者に対しても同様に記載し、署名を  
すること。)

(Supply similar information and signature for second  
and subsequent joint inventors.)

0651-0032 (8-98)